

## C L A I M S

1. A short-range radar comprising:
  - a transmitter section which radiates a short pulse wave having a predetermined width into space each time receiving a transmission trigger signal;
  - a receiver section which performs reception and detection processing on a reflected wave of the short pulse wave when having received a reception trigger signal;
- 10 a variable-period pulse generator including a direct digital synthesizer which outputs a signal having a frequency corresponding to frequency data specified from an outside, the variable-period pulse generator generating a variable-period pulse whose period changes in accordance with the frequency data;
- 15 a first pulse generation circuit which receives the variable-period pulse generated by the variable-period pulse generator, and which outputs a first pulse whose level shifts in a predetermined direction as the transmission trigger signal at a reference timing that is assumed to be a timing at which a level of the variable-period pulse shifts in a predetermined direction first since a search instruction is input;
- 20 a second pulse generation circuit which receives the variable-period pulse generated by the variable-period pulse generator, and which outputs as the reception trigger signal a second pulse whose level
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shifts in a predetermined direction at a timing when the level of the variable-period pulse has shifted in a direction opposite to the first predetermined direction after the reference timing;

5           a trigger signal generating section including the variable-period pulse generator, the first pulse generation circuit, and the second pulse generation circuit, the trigger signal generating section outputting the transmission trigger signal from the  
10          first pulse generation circuit to the transmitter section each time the variable-period pulse generator receives the search instruction, and also outputting from the second pulse generation circuit to the receiver section as the reception trigger signal a  
15          signal that is delayed by an arbitrary lapse of time with respect to the transmission trigger signal in order to give delay time between transmission and reception; and

20          a frequency data varying section including a memory in which a relationship between the frequency data and the delay time between transmission and reception is stored beforehand in a form of a table of computation expressions or calculation results, the frequency data varying section varying the frequency  
25          data destined for the direct digital synthesizer in the variable-period pulse generator based on the relationship between the frequency data and the delay

time between transmission and reception stored in the memory, thereby enabling arbitrarily varying delay time of the reception trigger signal with respect to the transmission trigger signal.

5       2. The short-range radar according to claim 1, having a fixed delay circuit which gives a delay of a fixed lapse of time to the first pulse from the first pulse generation circuit, and which outputs it as the transmission trigger signal, characterized in that

10       the second pulse generation circuit, when having received the variable-period pulse generated by the variable-period pulse generator, outputs the reception trigger signal at a timing when a lapse of time equal to an integral multiple of half a period of the variable-period pulse and longer than the fixed lapse of time has elapsed since the reference timing.

15       3. The short-range radar according to claim 1, characterized in that the receiver section comprises:

20       a branch circuit which divides in-phase a signal of the reflected wave of the short pulse wave radiated into the space by the transmitter section into first and second signals;

25       a linear multiplier which linear-multiplies the first and second signals that have been divided in-phase by the branch circuit; and

      a detector circuit configured by a low-pass filter which extracts a baseband component from an output

signal of the linear multiplier, and  
the short-range radar further comprises:  
a signal processing section which performs  
analysis processing on an object present in the space  
based on an output of the receiver section; and  
5 a control section which performs predetermined  
control on at least one of the transmitter section and  
the receiver section based on a result of analysis by  
the signal processing section.

10 4. The short-range radar according to claim 3,  
characterized in that the linear multiplier in the  
detector circuit is configured by a Gilbert mixer.

15 5. The short-range radar according to claim 3,  
characterized in that the receiver section has a  
sample-and-hold circuit which integrates an output  
signal of the detector circuit and which holds and  
outputs a result of the integration.

20 6. The short-range radar according to claim 5,  
characterized in that the control section variably  
controls an integration start timing and integration  
time of the sample-and-hold circuit based on a result  
of processing by the signal processing section.

25 7. The short-range radar according to claim 3,  
characterized in that

the transmitter section is provided with a power  
amplifier which amplifies the short pulse wave and the  
receiver section is provided with a low-noise amplifier

which amplifies a signal of the reflected wave, and  
the control section controls a gain of at least  
one of the power amplifier provided to the transmitter  
section and the low-noise amplifier provided to the  
5 receiver section such that a level of the signal of the  
reflected wave input to the detector circuit falls in a  
linear-operation range of the linear-multiplier in the  
receiver section.

8. The short-range radar according to claim 1,  
10 characterized in that the transmitter section is  
provided with a pulse generator which generates a pulse  
signal having a predetermined width and an oscillator  
which oscillates and provides an output signal as the  
short pulse wave only in a period in which the pulse  
15 signal from the pulse generator is being input, the  
oscillator stopping oscillation in a period in which  
the pulse signal is not being input.

9. A short-range radar comprising:  
a transmitter section which radiates a short pulse  
20 wave having a predetermined width into space each time  
receiving a transmission trigger signal;

a receiver section which performs reception and  
detection processing on a reflected wave of the short  
pulse wave when having received a reception trigger  
25 signal;

a variable-period pulse generator including a  
direct digital synthesizer which outputs a signal

having a frequency corresponding to frequency data specified from an outside based on a search instruction, the variable-period pulse generator generating a variable-period pulse whose period changes  
5 in accordance with the frequency data;

a first pulse generation circuit which receives the variable-period pulse generated by the variable-period pulse generator, and which outputs a first pulse at a reference timing that is assumed to be a timing at  
10 which a level of the variable-period pulse rises or falls;

15 a fixed delay circuit which gives a delay of a fixed lapse of time to the first pulse from the first pulse generation circuit, and which outputs it as the transmission trigger signal;

20 a second pulse generation circuit which receives the variable-period pulse generated by the variable-period pulse generator, and which outputs the reception trigger signal at a timing when a lapse of time that is equal to an integral multiple of half a period of the variable-period pulse and longer than the fixed lapse  
25 of time has elapsed since the reference timing;

25 a trigger signal generating section including the variable-period pulse generator, the first pulse generation circuit, the fixed delay circuit, and the second pulse generation circuit, the trigger signal generating section outputting the transmission trigger

signal from the fixed delay circuit to the transmitter section each time the variable-period pulse generator receives the search instruction, and also outputting from the second pulse generation circuit to the receiver section as the reception trigger signal a signal that is delayed by an arbitrary lapse of time with respect to the transmission trigger signal in order to give delay time between transmission and reception; and

10 a frequency data varying section including a memory in which a relationship between the frequency data and the delay time between transmission and reception is stored beforehand in a form of a table of computation expressions or calculation results, the frequency data varying section varying the frequency data destined for the direct digital synthesizer in the variable-period pulse generator based on the relationship between the frequency data and the delay time between transmission and reception stored in the memory, thereby enabling arbitrarily varying delay time of the reception trigger signal with respect to the transmission trigger signal.

15 10. The short-range radar according to claim 9, characterized in that

20 25 the first pulse generation circuit, when having received the variable-period pulse generated by the variable-period pulse generator, outputs a first pulse

whose level rises at the reference timing, and  
the second pulse generation circuit, when having  
received the variable-period pulse generated by the  
variable-period pulse generator, outputs as the  
5 reception trigger signal a signal whose level rises at  
a timing when a lapse of time equal to an integral  
multiple of half a period of the variable-period pulse  
and longer than the fixed lapse of time has elapsed  
since the reference timing.

10 11. The short-range radar according to claim 9,  
characterized in that the receiver section comprises:  
a branch circuit which divides in-phase a signal  
of the reflected wave of the short pulse wave radiated  
into the space by the transmitter section into first  
15 and second signals;  
a linear multiplier which linear-multiplies the  
first and second signals that have been divided in-  
phase by the branch circuit; and  
a detector circuit configured by a low-pass filter  
20 which extracts a baseband component from an output  
signal of the linear multiplier, and  
the short-range radar further comprises:  
a signal processing section which performs  
analysis processing on an object present in the space  
25 based on an output of the receiver section; and  
a control section which performs predetermined  
control on at least one of the transmitter section and

the receiver section based on a result of analysis by the signal processing section.

12. The short-range radar according to claim 11, characterized in that the linear multiplier in the 5 detector circuit is configured by a Gilbert mixer.

13. The short-range radar according to claim 11, characterized in that the receiver section has a sample-and-hold circuit which integrates an output signal of the detector circuit and which holds and 10 outputs a result of the integration.

14. The short-range radar according to claim 13, characterized in that the control section variably controls an integration start timing and integration time of the sample-and-hold circuit based on a result 15 of processing by the signal processing section.

15. The short-range radar according to claim 11, characterized in that

the transmitter section is provided with a power 20 amplifier which amplifies the short pulse wave and the receiver section is provided with a low-noise amplifier which amplifies a signal of the reflected wave, and

the control section controls a gain of at least one of the power amplifier provided to the transmitter section and the low-noise amplifier provided to the 25 receiver section such that a level of the signal of the reflected wave input to the detector circuit falls in a linear-operation range of the linear-multiplier in the

receiver section.

16. The short-range radar according to claim 9, characterized in that the transmitter section is provided with a pulse generator which generates a pulse signal having a predetermined width and an oscillator which oscillates and provides an output signal as the short pulse wave only in a period in which the pulse signal from the pulse generator is being input, the oscillator stopping oscillation in a period in which the pulse signal is not being input.

10 17. A short-range radar control method comprising:

15 a step of preparing a transmitter section and a receiver section;

20 a step of radiating a short pulse wave having a predetermined width into space by using the transmitter section each time a transmission trigger signal is received;

25 a step of receiving a reception trigger signal by using the receiver section, to perform reception and detection processing on a reflected wave of the short pulse wave;

30 a step of generating a variable-period pulse whose frequency changes in accordance with frequency data specified from outside, by using a direct digital synthesizer which outputs a signal having a frequency corresponding to the frequency data based on a search

instruction;

5 a step of outputting as the transmission trigger signal a first pulse whose level shifts in a predetermined direction at a reference timing that is assumed to be a timing at which a level of the variable-period pulse shifts first in a predetermined direction;

10 a step of outputting as the reception trigger signal a second pulse whose level shifts in a predetermined direction at a timing when the level of the variable-period pulse has shifted in a direction opposite to the first predetermined direction after the reference timing;

15 a step of, including: the step of generating the variable-period pulse; the step of outputting the first pulse as the transmission trigger signal; and the step of outputting the second pulse as the reception trigger signal, outputting the transmission trigger signal to the transmitter section in the step of outputting the first pulse as the transmission trigger signal each time the search instruction is received in the step of generating the variable-period pulse, and also outputting to the receiver section as the reception trigger signal a signal delayed by an arbitrary lapse of time with respect to the transmission trigger signal in order to give delay time between transmission and reception, in the step of outputting the second pulse

as the reception trigger signal;

5 a step of storing beforehand in a memory a relationship between the frequency data and the delay time between transmission and reception in a form of a table of computation expressions or calculation results; and

10 a step of varying the frequency data destined for the direct digital synthesizer for use in the step of generating the variable-period pulse based on the relationship between the frequency data and the delay time between transmission and reception stored in the memory, thereby enabling arbitrarily varying delay time of the reception trigger signal with respect to the transmission trigger signal.

15 18. The short-range radar control method according to claim 17, characterized in that

20 the step of outputting the first pulse as the transmission trigger signal has a step of giving a delay of a fixed lapse of time to the first pulse by using a fixed delay circuit, and

25 the step of outputting the second pulse as the reception trigger signal outputs the reception trigger signal at a timing when a lapse of time equal to an integral multiple of half a period of the variable-period pulse and longer than the fixed lapse of time has elapsed since the reference timing.

19. The short-range radar control method

according to claim 17, characterized in that  
the step of performing the reception and detection  
processing comprises:

5 a step of receiving a signal of the reflected wave  
of the short pulse wave radiated into the space by  
using the receiver section and dividing in-phase the  
signal of the reflected wave into first and second  
signals;

10 a step of linear-multiplying the first and second  
signals by using a linear multiplier and outputting a  
linear-multiplied signal;

a step of extracting a baseband component from the  
linear-multiplied signal;

15 a step of performing analysis processing on an  
object present in the space based on the baseband  
component; and

a step of performing predetermined control on at  
least one of the transmitter section and the receiver  
section based on a result of the analysis processing.

20 20. The short-range radar control method  
according to claim 19, characterized in that the step  
of outputting the linear-multiplied signal comprises:

25 a step of performing linear multiplication for the  
purpose of outputting the linear-multiplied signal by  
using a Gilbert mixer as the linear multiplier.

21. The short-range radar control method  
according to claim 19, characterized by further

comprising a step of integrating the baseband component and holding and outputting a result of the integration before the step of performing analysis processing.

22. The short-range radar control method  
5 according to claim 21, characterized in that the step of integrating the baseband component comprises:

10 a step of performing variable control on a timing for starting integration of the baseband component and integration time based on a result of the analysis processing.

23. The short-range radar control method  
according to claim 19, characterized in that  
15 the transmitter section is provided with a power amplifier which amplifies the short pulse wave and the receiver section is provided with a low-noise amplifier which amplifies a signal of the reflected wave, and  
the step of performing the predetermined control comprises:

20 a step of controlling a gain of at least one of the power amplifier provided to the transmitter section and the low-noise amplifier provided to the receiver section such that a level of the signal of the reflected wave falls in a linear-operation range of the linear-multiplier in the receiver section.

25 24. The short-range radar control method  
according to claim 17, characterized in that the step of radiating the short pulse wave into the space by

using the transmitter section comprises:

a step of generating a pulse signal having a predetermined width;

5 a step of performing an oscillation operation only in a period in which the pulse signal is being input, and outputting an output signal as the short pulse wave; and

10 a step of stopping the oscillation operation in a period in which the pulse signal is not input, to avoid output of the output signal as the short pulse signal.

25. A short range radar control method comprising:

a step of preparing a transmitter section and a receiver section;

15 a step of radiating a short pulse wave having a predetermined width into space by using the transmitter section each time a transmission trigger signal is received;

20 a step of receiving a reception trigger signal by using the receiver section, to perform reception and detection processing on a reflected wave of the short pulse wave;

25 a step of generating a variable-period pulse whose frequency changes in accordance with frequency data specified from outside, by using a direct digital synthesizer which outputs a signal having a frequency corresponding to the frequency data based on a search

instruction;

a step of outputting a first pulse at a reference timing that is assumed to be a timing at which the variable-period pulse rises or falls;

5 a step of giving a delay of a fixed lapse of time to the first pulse, and outputting it as the transmission trigger signal;

10 a step of outputting the reception trigger signal at a timing when a lapse of time that is equal to an integral multiple of half a period of the variable-period pulse and longer than the fixed lapse of time has elapsed since the reference timing;

15 a step of, including: the step of generating the variable-period pulse; the step of outputting the first pulse; the step of giving the fixed lapse of time to the first pulse and outputting it as the transmission trigger signal; and the step of outputting the reception trigger signal at a timing when the lapse of time longer than the fixed lapse of time has elapsed,  
20 outputting the transmission trigger signal to the transmitter section in the step of giving the fixed lapse of time to the first pulse and outputting it as the transmission trigger signal each time the search instruction is received in the step of generating the variable-period pulse and also outputting to the receiver section as the reception trigger signal a signal delayed by an arbitrary lapse of time with  
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respect to the transmission trigger signal at a timing when the lapse of time longer than the fixed lapse of time has elapsed in order to give delay time between transmission and reception, in the step of outputting  
5 as the reception trigger signal;

a step of storing beforehand in a memory a relationship between the frequency data and the delay time between transmission and reception in a form of a table of computation expressions or calculation  
10 results; and

a step of varying the frequency data destined for the direct digital synthesizer for use in the step of generating the variable-period pulse based on the relationship between the frequency data and the delay  
15 time between transmission and reception stored in the memory, thereby enabling arbitrarily varying delay time of the reception trigger signal with respect to the transmission trigger signal.

26. The short range radar control method  
20 according to claim 25, characterized in that

the step of generating the first pulse outputs a first pulse whose level rises at the reference timing, and

the step of outputting the reception trigger  
25 signal at the timing when the lapse of time longer than the fixed lapse of time has elapsed outputs as the reception trigger signal a signal whose level rises at

a timing when a lapse of time equal to an integral multiple of half a period of the variable-period pulse and longer than the fixed lapse of time has elapsed since the reference timing.

5        27. The short-range radar control method according to claim 25, characterized in that the step of performing the reception and detection processing comprises:

10      a step of receiving a signal of the reflected wave of the short pulse wave radiated into the space by using the receiver section and dividing in-phase the signal of the reflected wave into first and second signals;

15      a step of linear-multiplying the first and second signals by using a linear multiplier and outputting a linear-multiplied signal;

      a step of extracting a baseband component from the linear-multiplied signal;

20      a step of performing analysis processing on an object present in the space based on the baseband component; and

      a step of performing predetermined control on at least one of the transmitter section and the receiver section based on a result of the analysis processing.

25      28. The short-range radar control method according to claim 27, characterized in that the step of outputting the linear-multiplied signal comprises:

a step of performing linear multiplication for the purpose of outputting the linear-multiplied signal by using a Gilbert mixer as the linear multiplier.

29. The short-range radar control method  
5 according to claim 27, characterized by further comprising a step of integrating the baseband component and holding and outputting a result of the integration before the step of performing the analysis processing.

30. The short-range radar control method  
10 according to claim 29, characterized in that the step of integrating the baseband component comprises:

15 a step of performing variable control on a timing for starting integration of the baseband component and integration time based on a result of the analysis processing.

31. The short-range radar control method  
according to claim 27, characterized in that  
the transmitter section is provided with a power  
amplifier which amplifies the short pulse wave and the  
20 receiver section is provided with a low-noise amplifier  
which amplifies a signal of the reflected wave, and  
the step of performing the predetermined control  
comprises:

25 a step of controlling a gain of at least one of  
the power amplifier provided to the transmitter section  
and the low-noise amplifier provided to the receiver  
section such that a level of the signal of the

reflected wave falls in a linear-operation range of the linear-multiplier in the receiver section.

32. The short-range radar control method according to claim 25, characterized in that the step 5 of radiating the short pulse wave into the space by using the transmitter section comprises:

a step of generating a pulse signal having a predetermined width;

10 a step of performing an oscillation operation only in a period in which the pulse signal is being input, and outputting an output signal as the short pulse wave; and

15 a step of stopping the oscillation operation in a period in which the pulse signal is not input, to avoid output of the output signal as the short pulse signal.